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Highly enantioselective conjugate additions of potassium organotrifluoroborates to enones using monodentate phosphoramidite ligands.

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Supporting information

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General experimental

All reactions were performed in a dry nitrogen atmosphere using standard Schlenk techniques or in a glove box. Reagent grade dried solvents were purchased from Fluka and used as received. Amines and enones were used as received; 2,3-dimethyl-2,3-dihydro-1H-indole (**L31**), nipecotate (**L32**), and perhydroisoquinoline (**L33**) were used as mixtures of stereoisomers. Triethylamine was stored over KOH pellets. ^{1}H-, ^{13}C-, and ^{31}P-NMR spectra were recorded on a Varian Gemini 200 (200, 75, and 81 MHz, respectively) using $CDCl_3$ as solvent. Chemical shifts are reported in ppm with the $CHCl_3$ resonance as the internal standard for ^{1}H (δ 7.25), $CDCl_3$ for ^{13}C (δ 77.0), and external 85% H_3PO_4 for ^{31}P-NMR (δ 0.0). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, br = broad, m = multiplet), coupling constants (Hz), and integration. Optical rotations were measured on a Perkin Elmer 241 polarimeter. Mass spectra were recorded on a AEI-MS-902 mass spectrometer. Enantiomeric excesses and conversions were determined by capillary GC analysis on a HP 6890 gas chromatograph equiped with a flame ionisation detector, or by chiral HPLC analysis on a Shimaszu LC-10AD*VP* HPLC equiped with a Shimadzu SPD-M10A*VP* diode array detector. The library was synthesized using a Zinsser Lissy liquid handling robot equipped with 4 probes and placed inside a glove box. Whatman PKP 2mL 96-well filter plates in combination with the UniVac 3 vacuum manifold were used to perform the parallel filtration of the ligand library. The reactions were carried out in a Premex 96-Multi Reactor that can accommodate 96 reactions vessels at the same temperature.[1]

Literature preparations

The following compounds were prepared by literature methods: potassium vinyltrifluoroborate (**2**),[2] potassium propenyltrifluoroborate (**4**),[2] potassium methyltrifluoroborate (**6**),[3] potassium hexynyltrifluoroborate (**7**),[4] potassium phenyltrifluoroborate (**12**),[2] potassium tolyltrifluoroborate (**14**),[2] potassium 3-chloro-phenyltrifluoroborate (**15**),[2] potassium 3-methoxy-phenyltrifluoroborate (**16**),[2] and potassium 3-thiophenyltrifluoroborate (**17**).[2] Phosphoramidite ligands **L1A**,[5] **L1B**,[6] **L2A**,[7] **L3D**,[8] **L4A**,[7] **L5A**,[7] **L5B**,[9] **L6A**,[10] **L7A**,[7] **L7B**,[10] **L8A**,[7] **L8B**,[10] **L9A**,[7] **L10B**,[10] **L11B**,[10] **L12A**,[10] **L13A**,[7] **L14A**,[7] and **L19A**.[10]

Spectral and chromatographic data of isolated conjugate addition compounds

The following compounds were prepared according to the general procedure for conjugate addition of potassium organotrifluoroborates, and spectral data were in accordance with literature: 3-vinyl-cyclohexanone (**3**),[11] enantiomer separation by chiral GC, Chiraldex A-TA column, 30m x 0.25 mm, 90^{o}C isothermic, 11.8 / 12.4 min. 3-Propenyl-cyclohexanone (**8**),[12] enantiomer separation by chiral GC, Chiraldex G-TA column, 30m x 0.25 mm, 105^{o}C isothermic, 10.1 / 10.3 min. 3-Styryl-cyclohexanone (**9**),[13] enantiomer separation by chiral HPLC, Daicel OD column, heptanes/isopropanol 99/1, 20.6 / 22.7 min. 3-Phenyl-cyclohexanone (**13**),[9] enantiomer separation by chiral GC, Chiraldex A-TA column, 30m x 0.25 mm, 120^{o}C isothermic, 59.5 / 61.5 min. 3-*p*-Tolyl-cyclohexanone (**18**),[9] enantiomer separation by chiral HPLC, Daicel AS column, heptanes/isopropanol 99/1, 11.7 / 12.6 min. 3-(3-Chloro-phenyl)-cyclohexanone (**19**),[14] enantiomer separation by chiral HPLC, Daicel OD column, heptanes/isopropanol 95/5, 7.6 / 8.1 min. 3-(3-Methoxy-phenyl)-cyclohexanone (**20**),[9] enantiomer separation by chiral HPLC, Daicel OD column, heptanes/isopropanol 95/5, 12.6 / 14.0 min. 3-Thiophen-3-yl-cyclohexanone (**21**),[14] enantiomer separation by chiral GC, Chiraldex A-TA column, 30m x 0.25 mm, 125^{o}C isothermic, 55.3 / 57.5 min. 3-Phenyl-cyclopentanone (**25**),[9] enantiomer separation by chiral HPLC, Daicel OBH column, heptanes/isopropanol 99/1, 35.0 / 37.2 min. 3-Phenyl-cycloheptanone (**26**),[9] enantiomer separation by chiral HPLC, Daicel OD column, heptanes/isopropanol 95/5, 6.9 / 7.4 min. 4-Phenyl-tetrahydro-pyran-2-one (**27**),[9] enantiomer separation by chiral GC, Chiraldex G-TA column, 30m x 0.25 mm, 150^{o}C isothermic, 14.3 / 17.0 min. 4-Phenyl-hex-5-en-2-one (**29**),[15] enantiomer separation by chiral GC, Chiraldex G-TA column, 30m x 0.25 mm, 120^{o}C isothermic, 14.0 / 14.3 min.

Spectral and analytical data of isolated ligands

The following ligands were prepared according to the general procedure for phosphoramidite synthesis.

L6B as a white foam (319 mg, 60%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 1.51-1.81 (m, 12H); 2.16-2.33 (m, 2H); 2.58-2.85 (m, 8H); 3.02-3.11 (m, 2H); 6.99 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 22.5; 22.7; 22.8; 25.8 (d, *J* = 4.2 Hz); 27.7 (d, *J* = 6.4 Hz); 29.1 (d, *J* = 5.6 Hz); 45.4 (d, *J* = 15.5 Hz); 118.4; 129.2 (d, *J* = 15.5 Hz); 133.8 (d, *J* = 47.0 Hz); 137.8 (d, *J* = 21.6 Hz); 148.9 (d, *J* = 26.5 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 142.7 ppm. HRMS calcd for $C_{24}H_{28}NO_2P$: 393.18575, found 393.18462. Anal. calcd for $C_{24}H_{28}NO_2P$: C 73.26 H 7.17 N 3.56, found C 73.10 H 7.32 N 3.55. Mp 67 ˚C. $[\alpha]_D$ = + 266˚, (c = 1.0, $CHCl_3$).

L15A as a white foam (305 mg, 71%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.90 (m, 3H); 1.21-1.54 (m, 8H); 2.34 (d, *J* = 5.8 Hz, 3H); 3.10 (m, 2H); 7.18-7.51 (m, 8H); 7.93 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 14.0; 22.6; 26.1; 28.3 (d, *J* = 3.8 Hz); 31.5; 31.8 (d, *J* = 3.4 Hz); 49.8 (d, *J* = 36.8 Hz); 122.2 (d, *J* = 9.5 Hz); 124.6 (d, *J* = 12.9 Hz); 125.9 (d, *J* = 2.3 Hz); 127.0 (d, *J* = 4.5 Hz); 128.2 (d, *J* = 5.3 Hz); 130.1 (d, *J* = 20.5 Hz); 131.2 (d, *J* = 36.0 Hz); 132.8 (d, *J* = 10.2 Hz); 149.6, 150.1 (d, *J* = 5.3 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 148.5 ppm. HRMS calcd for $C_{27}H_{28}NO_2P$: 429.18575, found 429.18575. Anal. calcd for $C_{27}H_{28}NO_2P$: C 75.51 H 6.57 N 3.26, found C 75.80 H 6.50 N 3.21. Mp 52 ˚C. $[\alpha]_D$ = + 403˚, (c = 1.1, $CHCl_3$).

L16B as a white foam (304 mg, 80%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 1.10 (t, *J* = 7.0 Hz, 3H); 1.54 (m, 2H); 1.70-1.84 (m, 6H); 2.18-2.37 (m, 5H); 2.58-3.19 (m, 10H); 7.00 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 14.5; 22.5; 22.6; 27.7 (d, *J* = 6.8 Hz); 29.1 (d, *J* = 5.6 Hz); 31.3 (d, *J* = 6.8 Hz); 43.8 (d, *J*= 35.6 Hz); 118.5; 129.2 (d, *J* = 6.8 Hz); 133.9 (d, *J* = 49.7 Hz); 137.9 (d, *J* = 24.3 Hz); 148.7 (d, *J* = 17.0 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 142.0 ppm. HRMS calcd for $C_{23}H_{28}NO_2P$: 318.18575, found 318.18496. Anal. calcd for $C_{23}H_{28}NO_2P$: C 72.42 H 7.40 N 3.67, found C 72.50 H 7.42 N 3.59. Mp 88 ˚C. $[\alpha]_D$ = + 257˚, (c = 1.0, $CHCl_3$).

L17B as a colorless oil (237 mg, 57%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.74 (t, *J* = 7.4 Hz, 6H); 1.32-1.58 (m, 6H); 1.70-1.84 (m, 6H); 2.18-2.37 (m, 2H); 2.52-2.79 (m, 10H); 6.98 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 11.0; 21.5 (d, *J* = 3.4 Hz); 22.5; 22.6; 22.6; 27.7 (d, *J* = 7.2 Hz); 29.1 (d, *J* = 6.0 Hz); 31.6 (d, *J* = 3.4 Hz); 51.5 (d, *J*= 36.8 Hz); 118.5; 129.2 (d, *J* = 6.8 Hz); 133.8 (d, *J* = 49.7 Hz); 137.9 (d, *J* = 24.3 Hz); 148.7 (d, *J* = 17.0 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 142.3 ppm. HRMS calcd for $C_{24}H_{30}NO_2P$: 395.20140, found 395.20035. $[\alpha]_D$ = + 230˚, (c = 1.3, $CHCl_3$).

L18A as a white foam (453 mg, 75%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.83 (t, *J* = 7.6 Hz, 3H); 0.99 (t, *J* = 7.0 Hz, 3H); 1.41-1.56 (m, 2H); 2.66-3.03 (m, 4H); 7.19-7.51 (m, 8H); 7.92 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 11.1; 14.4; 21.7 (d, *J* = 2.7 Hz); 38.5 (d, *J* = 14.4 Hz); 46.1 (d, *J* = 27.0 Hz); 122.1 (d, *J* = 9.5 Hz); 124.6 (d, *J* = 12.9 Hz); 125.9 (d, *J* = 2.3 Hz); 127.0 (d, *J* = 4.5 Hz); 128.2 (d, *J* = 5.3 Hz); 130.1 (d, *J* = 20.5 Hz); 131.3 (d, *J* = 36.0 Hz); 132.7 (d, *J* = 10.2 Hz); 149.6, 150.1 (d, *J* = 5.3 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 148.9 ppm. HRMS calcd for $C_{25}H_{24}NO_2P$: 401.15445, found 401.15369. Anal. calcd for $C_{25}H_{24}NO_2P$: C 74.80 H 6.03 N 3.49, found C 74.80 H 6.36 N 3.50. Mp 59 ˚C. $[\alpha]_D$ = + 473˚, (c = 1.0, $CHCl_3$).

L18B as a colorless oil (471 mg, 76%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.78 (t, *J* = 7.2 Hz, 3H); 0.98 (t, *J* = 7.0 Hz, 3H); 1.41-1.56 (m, 4H); 1.71-1.80 (m, 6H); 2.18-2.37 (m, 2H); 2.52-2.79 (m, 10H); 7.02 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 11.0; 21.5 (d, *J* = 3.4 Hz); 22.5; 22.6; 22.6; 27.7 (d, *J* = 7.2 Hz); 29.1 (d, *J* = 6.0 Hz); 31.6 (d, *J* = 3.4 Hz); 51.5 (d, *J*= 36.8 Hz); 118.5; 129.2 (d, *J* = 6.8 Hz); 133.8 (d, *J* = 49.7 Hz); 137.9 (d, *J* = 24.3 Hz); 148.7 (d, *J* = 17.0 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 143.3 ppm. HRMS calcd for $C_{25}H_{32}NO_2P$: 409.21705, found 409.21750. $[\alpha]_D$ = + 222˚, (c = 1.0, $CHCl_3$).

L19B as a colorless oil (385 mg, 67%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.74 (t, *J* = 7.4 Hz, 6H); 1.32-1.58 (m, 6H); 1.70-1.84 (m, 6H); 2.18-2.37 (m, 2H); 2.52-2.79 (m, 10H); 6.98 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 11.2; 21.8 (d, *J* = 1.9 Hz); 22.5; 22.7; 22.8; 27.7 (d, *J* = 6.8 Hz); 29.1 (d, *J* = 7.6 Hz); 46.4 (d, *J*= 20.5 Hz); 118.6 (d, *J* = 11.0 Hz); 129.1 (d, *J* = 15.1 Hz); 133.7 (d, *J* = 45.9 Hz); 137.8 (d, *J* = 18.2 Hz); 148.7 (d, *J* = 26.5 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 143.5 ppm. HRMS calcd for $C_{26}H_{34}NO_2P$: 423.23270, found 423.23306. $[\alpha]_D$ = + 205˚, (c = 1.3, $CHCl_3$).

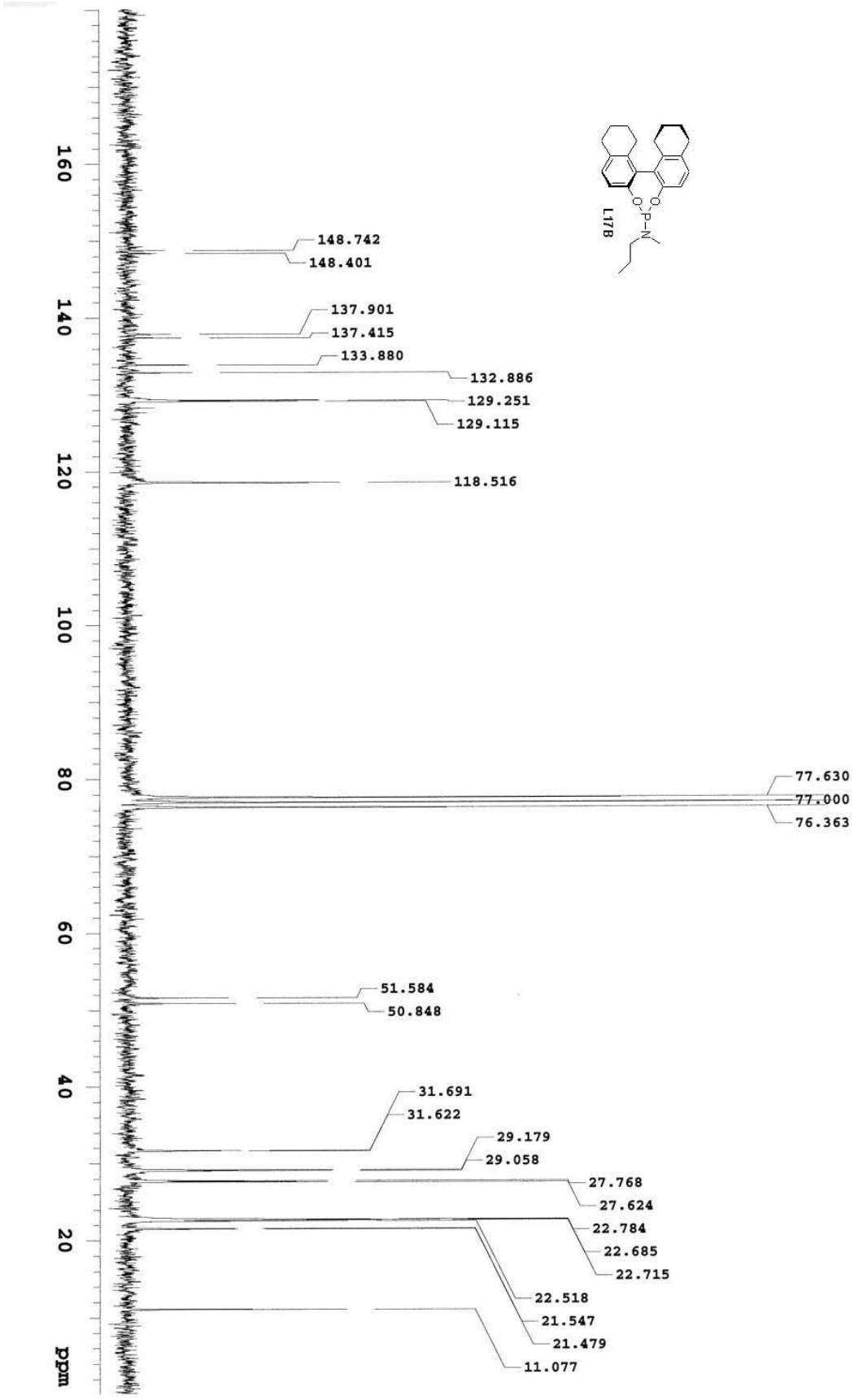
L20A as a white foam (481 mg, 77%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.85 (t, *J* = 7.4 Hz, 3H); 0.99 (t, *J* = 7.0 Hz, 3H); 1.16-1.32 (m, 2H); 1.38-1.53 (m, 2H); 2.66-3.04 (m, 4H); 7.19-7.51 (m, 8H); 7.92 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 13.7; 14.4; 19.8; 30.7 (d, *J* = 2.6 Hz); 38.5 (d, *J* = 14.8 Hz); 44.1 (d, *J* = 26.9 Hz); 122.1 (d, *J* = 9.5 Hz); 124.6 (d, *J* = 12.9 Hz); 125.9 (d, *J* = 2.3 Hz); 127.0 (d, *J* = 4.5 Hz); 128.2 (d, *J* = 5.3 Hz); 130.1 (d, *J* = 20.5 Hz); 131.2 (d, *J* = 36.0 Hz); 132.8 (d, *J* = 10.2 Hz); 149.6, 150.1 (d, *J* = 5.3 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 149.0 ppm. HRMS calcd for $C_{26}H_{26}NO_2P$: 415.17010, found 415.17117. Anal. calcd for $C_{26}H_{26}NO_2P$: C 75.16 H 6.31 N 3.37, found C 75.20 H 6.27 N 3.29. Mp 49 ˚C. $[\alpha]_D$ = + 440˚, (c = 1.1, $CHCl_3$).

L21A as a white foam (343 mg, 53%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.80 (m, 6H); 1.11-1.22 (m, 2H); 1.35-1.54 (m, 4H); 2.69-2.95 (m, 4H); 7.18-7.51 (m, 8H); 7.93 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 11.1; 13.7; 19.8; 21.5 (d, *J* = 2.3 Hz); 30.6 (d, *J* = 1.9 Hz); 44.2 (d, *J* = 20.1 Hz); 46.2 (d, *J* = 20.8 Hz); 122.2 (d, *J* = 9.5 Hz); 124.6 (d, *J* = 12.9 Hz); 125.9 (d, *J* = 2.3 Hz); 127.0 (d, *J* = 4.5 Hz); 128.2 (d, *J* = 5.3 Hz); 130.1 (d, *J* = 20.5 Hz); 131.2 (d, *J* = 36.0 Hz); 132.8 (d, *J* = 10.2 Hz); 149.6, 150.1 (d, *J* = 5.3 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 148.8 ppm. HRMS calcd for $C_{27}H_{28}NO_2P$: 429.18575, found 429.18477. Anal. calcd for $C_{27}H_{28}NO_2P$: C 75.51 H 6.57 N 3.26, found C 75.50 H 6.52 N 3.23. Mp 44 ˚C. $[\alpha]_D$ = + 433˚, (c = 1.1, $CHCl_3$).

L22A as a white foam (590 mg, 88%), ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.81 (t, *J* = 7.0Hz, 6H); 1.12-1.21 (m, 4H); 1.40-1.59 (m, 4H); 2.71-3.05 (m, 4H); 7.22-7.52 (m, 8H); 7.93 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 13.7; 19.8; 30.5; 44.2 (d, *J* = 20.8 Hz); 122.1 (d, *J* = 9.1 Hz); 124.6 (d, *J* = 12.5 Hz); 125.9; 127.0 (d, *J* = 4.9 Hz); 128.2 (d, *J* = 6.0 Hz); 130.1 (d, *J* = 20.8 Hz); 131.2 (d, *J* = 33.8 Hz); 132.8 (d, *J* = 10.2 Hz); 149.5, 150.1 (d, *J* = 5.3 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 149.0 ppm. HRMS calcd for $C_{28}H_{30}NO_2P$: 443.20140, found 443.20086. Anal. calcd for $C_{28}H_{30}NO_2P$: C 75.83 H 6.82 N 3.16, found C 76.10 H 7.09 N 3.19. Mp 42 ˚C. $[\alpha]_D$ = + 399˚, (c = 1.0, $CHCl_3$).

L23A as a colorless oil. ^{1}H-NMR (200 MHz, $CDCl_3$) δ 0.84 (t, *J* = 7.0 Hz, 6H); 1.09-1.21 (m, 8H); 1.40-1.54 (m, 4H); 2.72-3.00 (m, 4H); 7.20-7.54 (m, 8H); 7.94 (m, 4H) ppm. ^{13}C-NMR (50 MHz, $CDCl_3$) δ 13.9; 22.2; 28.1; 28.7; 44.4 (d, *J* = 33.2 Hz); 121.9; 122.1; 124.6 (d, *J* = 20.8 Hz); 125.9; 126.9 (d, *J* = 6.8 Hz); 128.2 (d, *J* = 11.0 Hz); 129.7; 130.1; 130.5; 131.2; 132.7 (d, *J* = 12.3 Hz); 149.6; 150.1 (d, *J*

= 5.3 Hz) ppm. ^{31}P-NMR (81 MHz, $CDCl_3$) δ 149.0 ppm. HRMS calcd for $C_{30}H_{34}NO_2P$: 471.232, found 471.233. $[\alpha]_D$ = + 366°, (c = 1.0, $CHCl_3$).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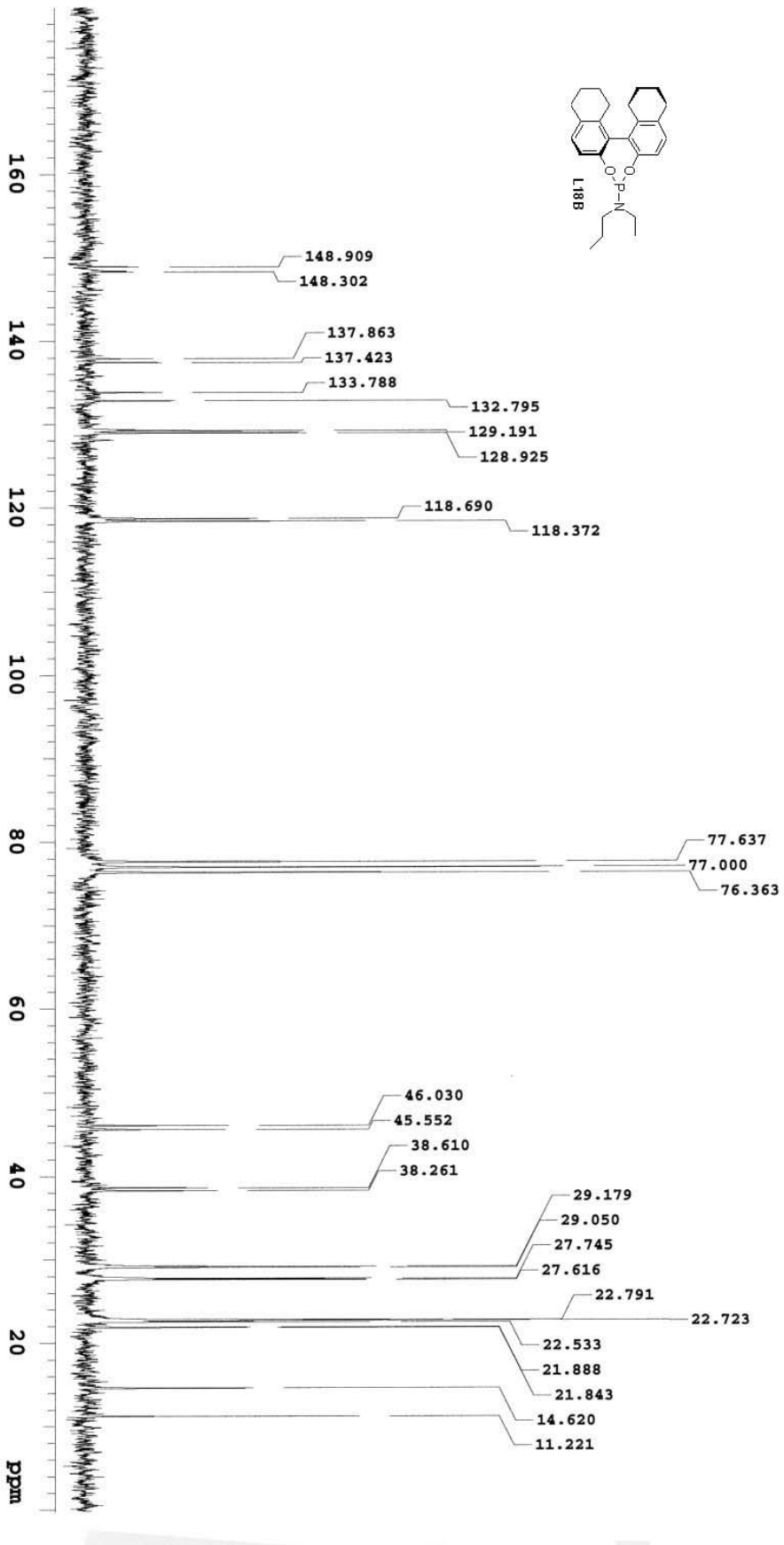
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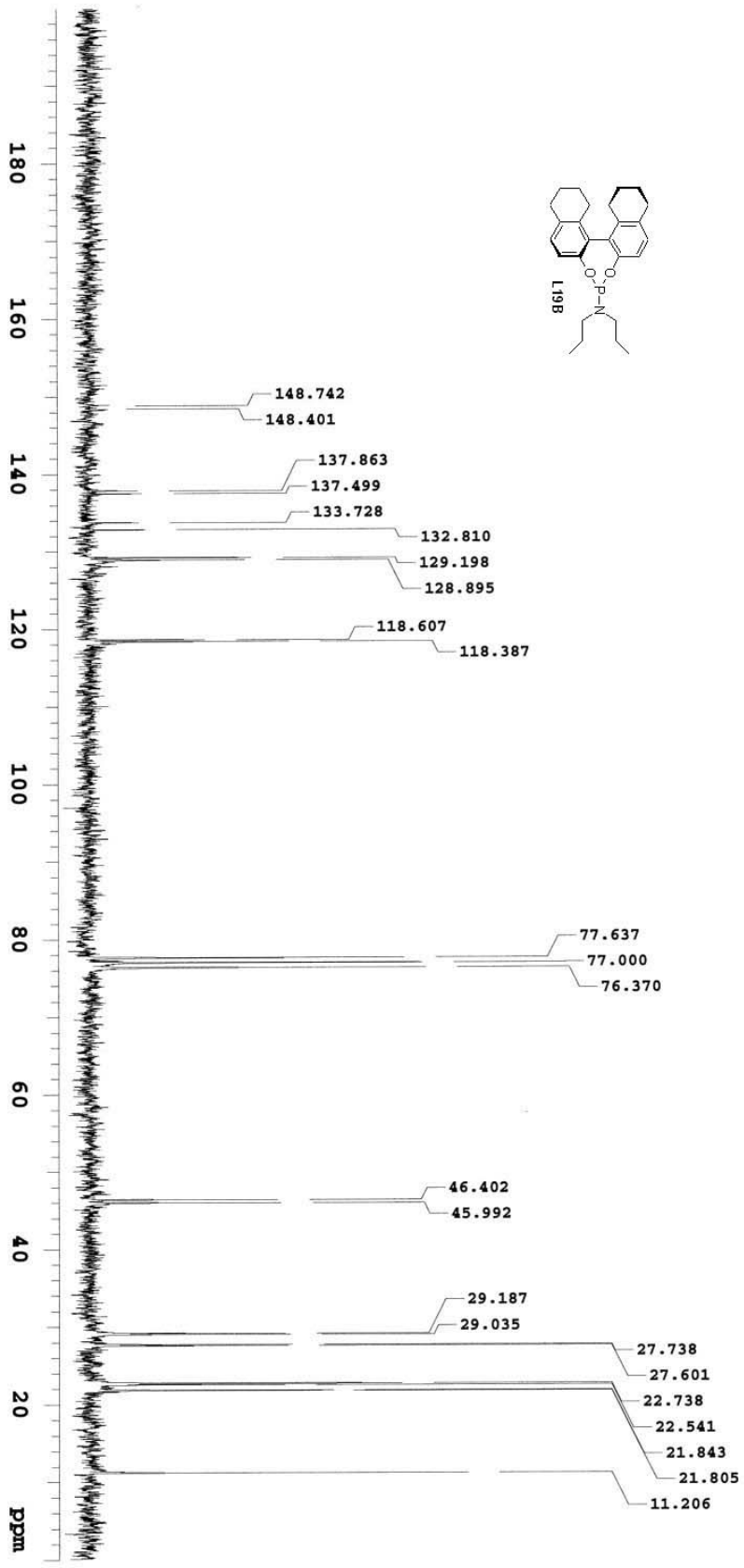
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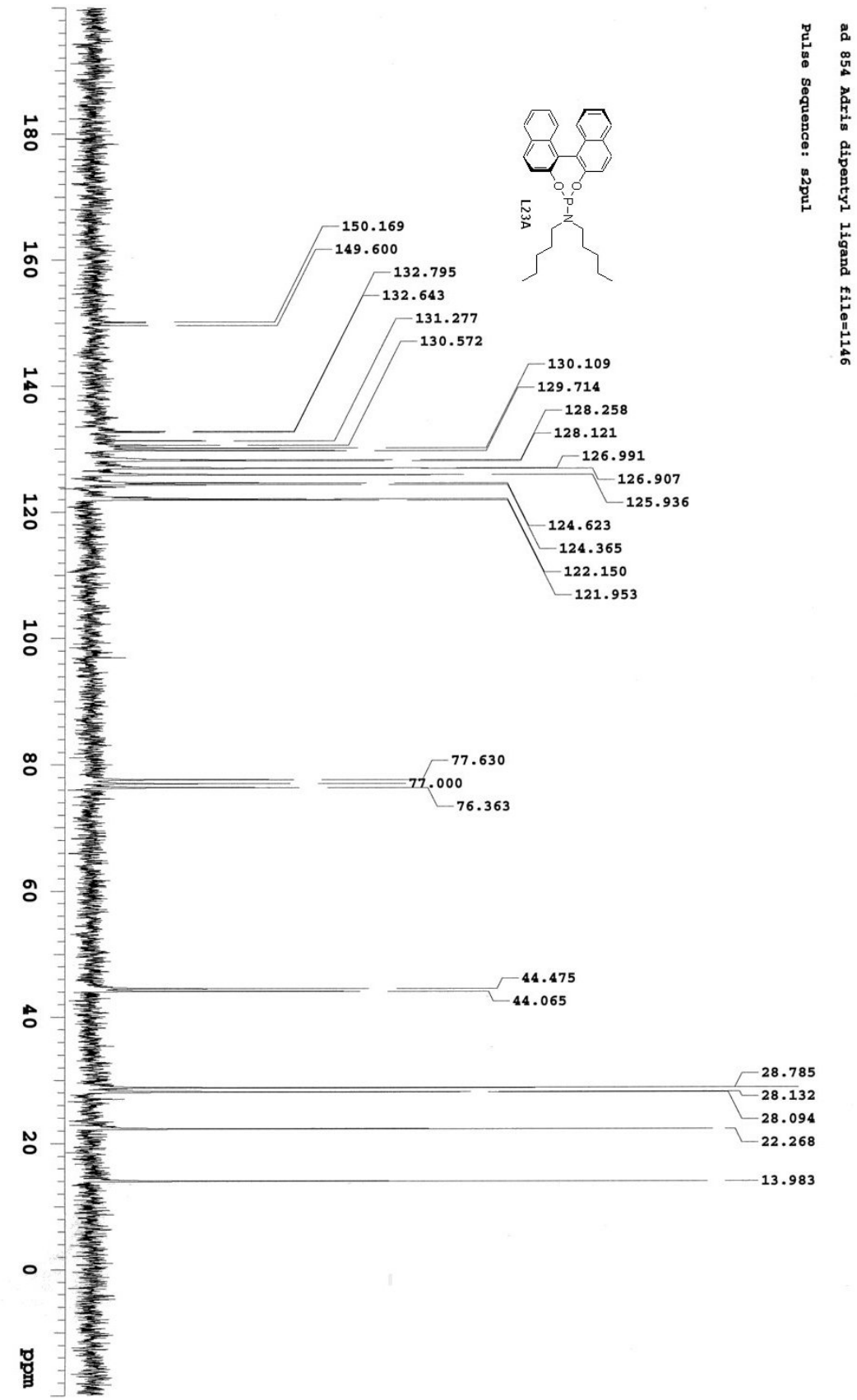
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80
60
40
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ppm

Quantitative data of the solution phase ligand library screening

For 2-cyclohexenone (**1**) the following results were obtained:

ligand (position)	conv. (%)	e.e. (%)	**ligand** (position)	conv. (%)	e.e. (%)	**ligand** (position)	conv. (%)	e.e. (%)
L11A (a1)	19	79	**L11B** (e1)	35	76	**L11C** (i1)	4	16
L26A (a2)	21	73	**L26B** (e2)	53	78	**L26C** (i2)	9	9
L30A (a3)	34	64	**L30B** (e3)	56	75	**L30C** (i3)	6	7
L33A (a4)	41	73	**L33B** (e4)	62	72	**L33C** (i4)	6	14
L36A (a5)	10	18	**L36B** (e5)	22	48	**L36C** (i5)	24	25
L40A (a6)	17	16	**L40B** (e6)	21	14	**L40C** (i6)	16	26
L44A (a7)	12	41	**L44B** (e7)	10	41	**L44C** (i7)	12	40
L16A (a8)	51	75	**L16B** (e8)	80	82	**L16C** (i8)	4	15
L5A (b1)	52	84	**L5B** (f1)	81	87	**L5C** (j1)	4	14
L27A (b2)	18	22	**L27B** (f2)	21	14	**L27C** (j2)	13	31
L31A (b3)	12	19	**L31B** (f3)	20	45	**L31C** (j3)	22	27
L34A (b4)	22	64	**L34B** (f4)	62	77	**L34C** (j4)	2	15
L37A (b5)	12	21	**L37B** (f5)	19	49	**L37C** (j5)	23	27
L41A (b6)	18	58	**L41B** (f6)	20	75	**L41C** (j6)	17	42
L45A (b7)	14	44	**L45B** (f7)	9	41	**L45C** (j7)	19	37
L48A (b8)	10	21	**L48B** (f8)	17	48	**L48C** (j8)	16	18
L24A (c1)	10	34	**L24B** (g1)	21	49	**L24C** (k1)	7	22
L28A (c2)	13	25	**L28B** (g2)	20	45	**L28C** (k2)	19	18
L7A (c3)	45	67	**L7B** (g3)	69	74	**L7C** (k3)	4	6
L35A (c4)	7	24	**L35B** (g4)	19	43	**L35C** (k4)	11	24
L38A (c5)	31	31	**L38B** (g5)	39	19	**L38C** (k5)	21	50
L42A (c6)	14	36	**L42B** (g6)	7	53	**L42C** (k6)	19	41
L46A (c7)	15	33	**L46B** (g7)	8	47	**L46C** (k7)	10	41
L9A (c8)	11	76	**L9B** (g8)	22	82	**L9C** (k8)	1	29
L25A (d1)	13	11	**L25B** (h1)	21	37	**L25C** (l1)	12	14
L29A (d2)	36	77	**L29B** (h2)	74	78	**L29C** (l2)	8	0
L32A (d3)	22	52	**L32B** (h3)	61	58	**L32C** (l3)	3	15
L22A (d4)	35	82	**L22B** (h4)	41	72	**L22C** (l4)	8	4
L39A (d5)	7	28	**L39B** (h5)	5	28	**L39C** (l5)	8	25
L43A (d6)	9	26	**L43B** (h6)	13	37	**L43C** (l6)	24	39
L47A (d7)	13	49	**L47B** (h7)	10	47	**L47C** (l7)	14	40
L49A (d8)	17	37	**L49B** (h8)	17	42	**L49C** (l8)	11	14

For benzylidene acetone (**28**) the following results were obtained:

ligand (position)	conv. (%)	e.e. (%)	**ligand** (position)	conv. (%)	e.e. (%)	**ligand** (position)	conv. (%)	e.e. (%)
L11A (a1)	69	10	**L11B** (e1)	92	7	**L11C** (i1)	14	10
L26A (a2)	82	22	**L26B** (e2)	84	15	**L26C** (i2)	17	12
L30A (a3)	92	31	**L30B** (e3)	88	33	**L30C** (i3)	13	4
L33A (a4)	99	23	**L33B** (e4)	96	21	**L33C** (i4)	20	13
L36A (a5)	1	0	**L36B** (e5)	6	25	**L36C** (i5)	10	9
L40A (a6)	16	34	**L40B** (e6)	42	28	**L40C** (i6)	8	6
L44A (a7)	35	21	**L44B** (e7)	52	24	**L44C** (i7)	16	5
L16A (a8)	99	17	**L16B** (e8)	96	8	**L16C** (i8)	17	4
L5A (b1)	99	8	**L5B** (f1)	88	3	**L5C** (j1)	15	5
L27A (b2)	28	24	**L27B** (f2)	49	29	**L27C** (j2)	9	6
L31A (b3)	6	12	**L31B** (f3)	1	25	**L31C** (j3)	9	10
L34A (b4)	77	40	**L34B** (f4)	99	30	**L34C** (j4)	11	4
L37A (b5)	15	35	**L37B** (f5)	26	26	**L37C** (j5)	10	10
L41A (b6)	31	37	**L41B** (f6)	24	23	**L41C** (j6)	8	4
L45A (b7)	38	18	**L45B** (f7)	35	19	**L45C** (j7)	13	7
L48A (b8)	28	32	**L48B** (f8)	44	27	**L48C** (j8)	13	10
L24A (c1)	22	43	**L24B** (g1)	49	34	**L24C** (k1)	4	5
L28A (c2)	21	36	**L28B** (g2)	2	28	**L28C** (k2)	16	11
L7A (c3)	78	37	**L7B** (g3)	99	25	**L7C** (k3)	16	4
L35A (c4)	12	41	**L35B** (g4)	16	27	**L35C** (k4)	10	9
L38A (c5)	35	32	**L38B** (g5)	49	31	**L38C** (k5)	14	6
L42A (c6)	32	28	**L42B** (g6)	36	29	**L42C** (k6)	19	7
L46A (c7)	33	16	**L46B** (g7)	40	21	**L46C** (k7)	17	5
L9A (c8)	63	30	**L9B** (g8)	83	22	**L9C** (k8)	3	8
L25A (d1)	22	30	**L25B** (h1)	13	30	**L25C** (l1)	6	10
L29A (d2)	91	14	**L29B** (h2)	99	24	**L29C** (l2)	16	15
L32A (d3)	89	42	**L32B** (h3)	99	40	**L32C** (l3)	11	24
L22A (d4)	70	2	**L22B** (h4)	99	17	**L22C** (l4)	22	29
L39A (d5)	15	22	**L39B** (h5)	36	26	**L39C** (l5)	21	8
L43A (d6)	34	32	**L43B** (h6)	52	26	**L43C** (l6)	12	3
L47A (d7)	30	25	**L47B** (h7)	70	23	**L47C** (l7)	16	4
L49A (d8)	45	33	**L49B** (h8)	37	31	**L49C** (l8)	16	8

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1 This reactor was developed by Premex in cooperation with DSM. See: www.premex-reactorag.ch/e/spezialloesungen/produkteneuheiten/

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